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science for a changing world

Long-Term Continuous Water-Quality Monitoring: An Example From Oregon

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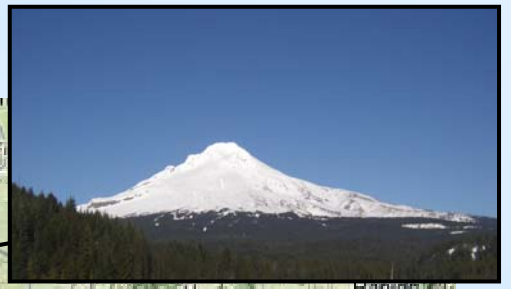
U.S. Geological Survey

Oregon



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photos by Stewart Rounds, USGS

The Willamette River in Recent Years

USGS

photos by USGS and U.S. Army Corps of Engineers

The Willamette River, circa 1940

In 1940, the Willamette River was pretty much an open sewer, with untreated wastes from cities, food processors, lumber mills, etc.

By the time the water arrived in Portland, its quality was very poor.

Photos from a 16mm film by the Oregon State Board of Health, http://oregonstate.edu/media/cbnnp-hiq

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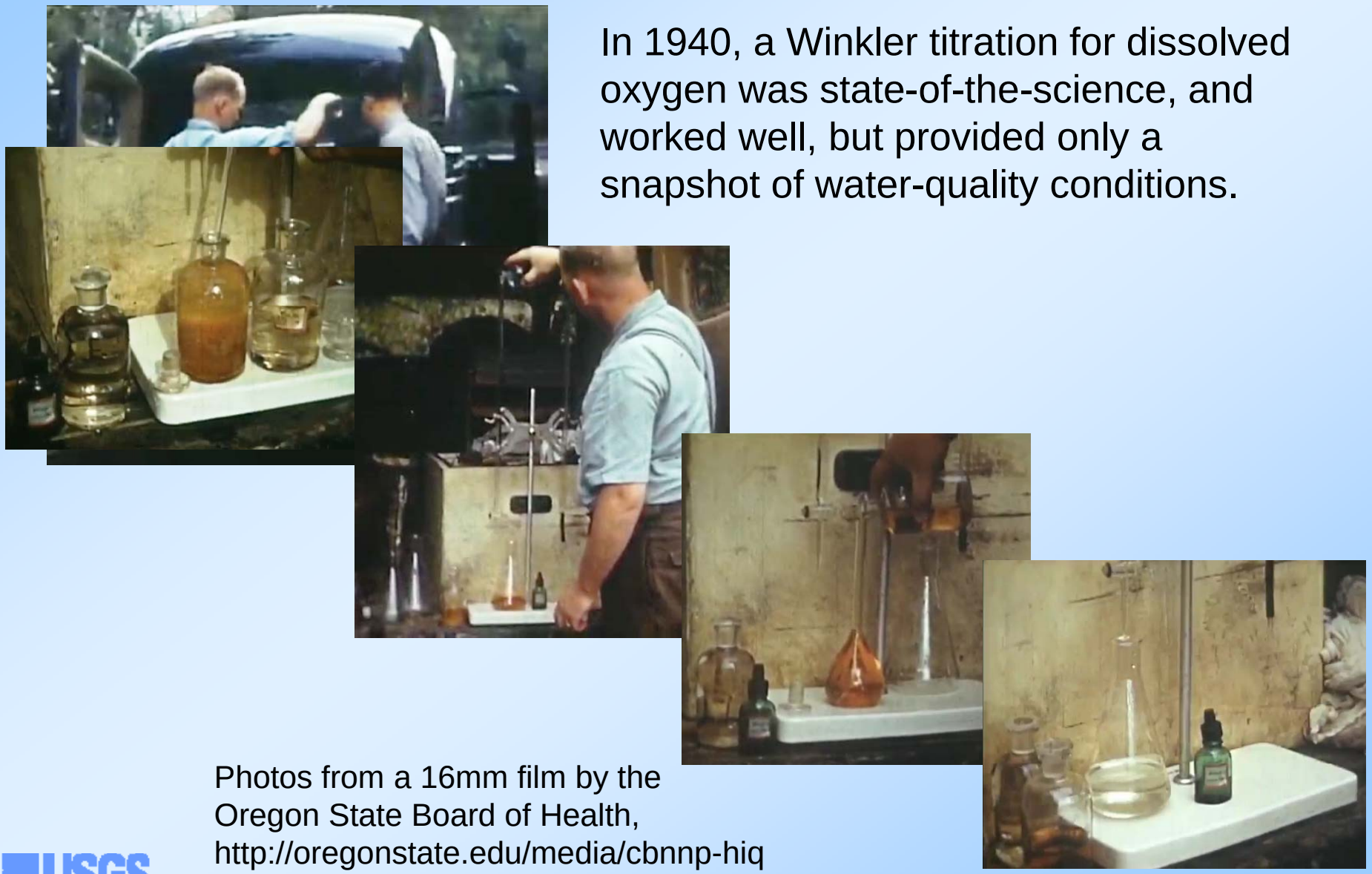
Water Quality Surveys Were Time-Consuming



In 1940, a Winkler titration for dissolved oxygen was state-of-the-science, and worked well, but provided only a snapshot of water-quality conditions.

Photos from a 16mm film by the Oregon State Board of Health, http://oregonstate.edu/media/cbnnp-hiq

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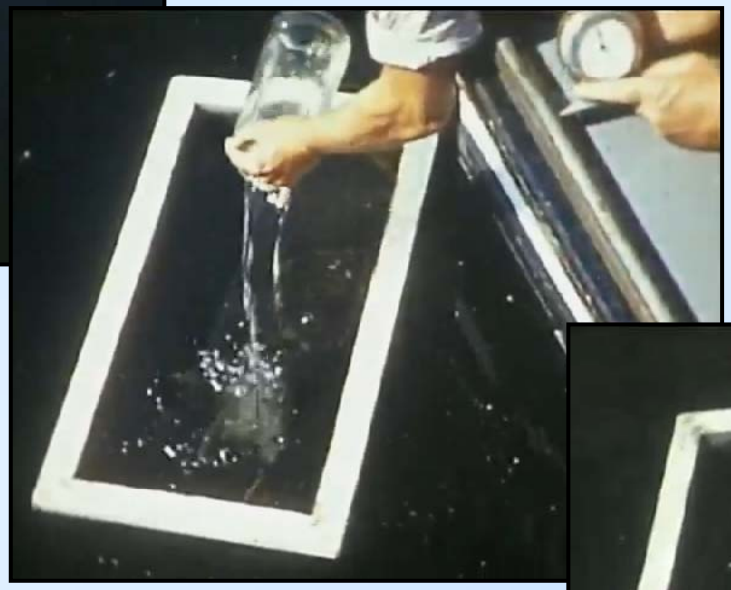
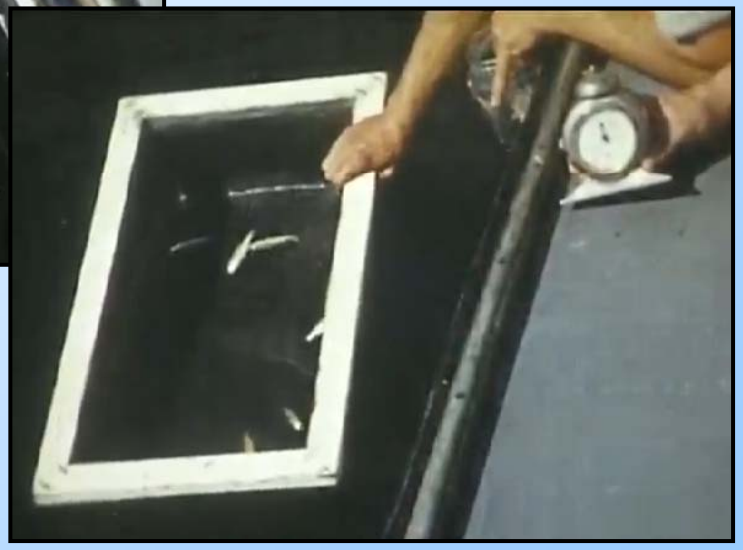
No Continuous WQ Monitors in 1940…

Here's an interesting way to test the water quality of the river…

Let's see how long fingerling salmon can survive…



…when we expose them to river water.



Photos from a 16mm film by the Oregon State Board of Health, http://oregonstate.edu/media/cbnnp-hiq

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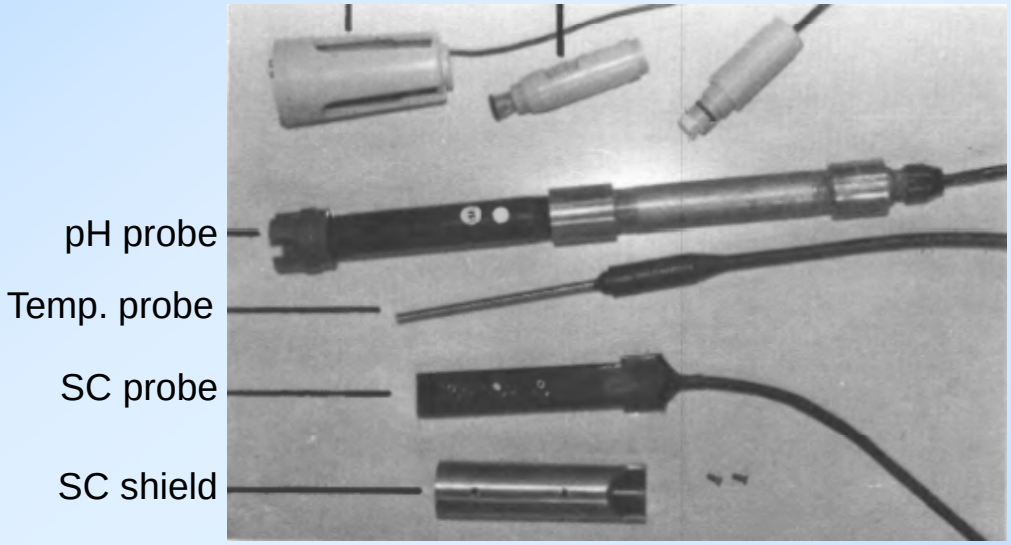
Instrumentation Sure Has Changed…

The USGS “mini-monitor” from the early 1990s was great at the time!

Water-quality instrumentation has come a long way since then…

(many manufacturers, no endorsement intended)



(photos from an old USGS report from Ohio)

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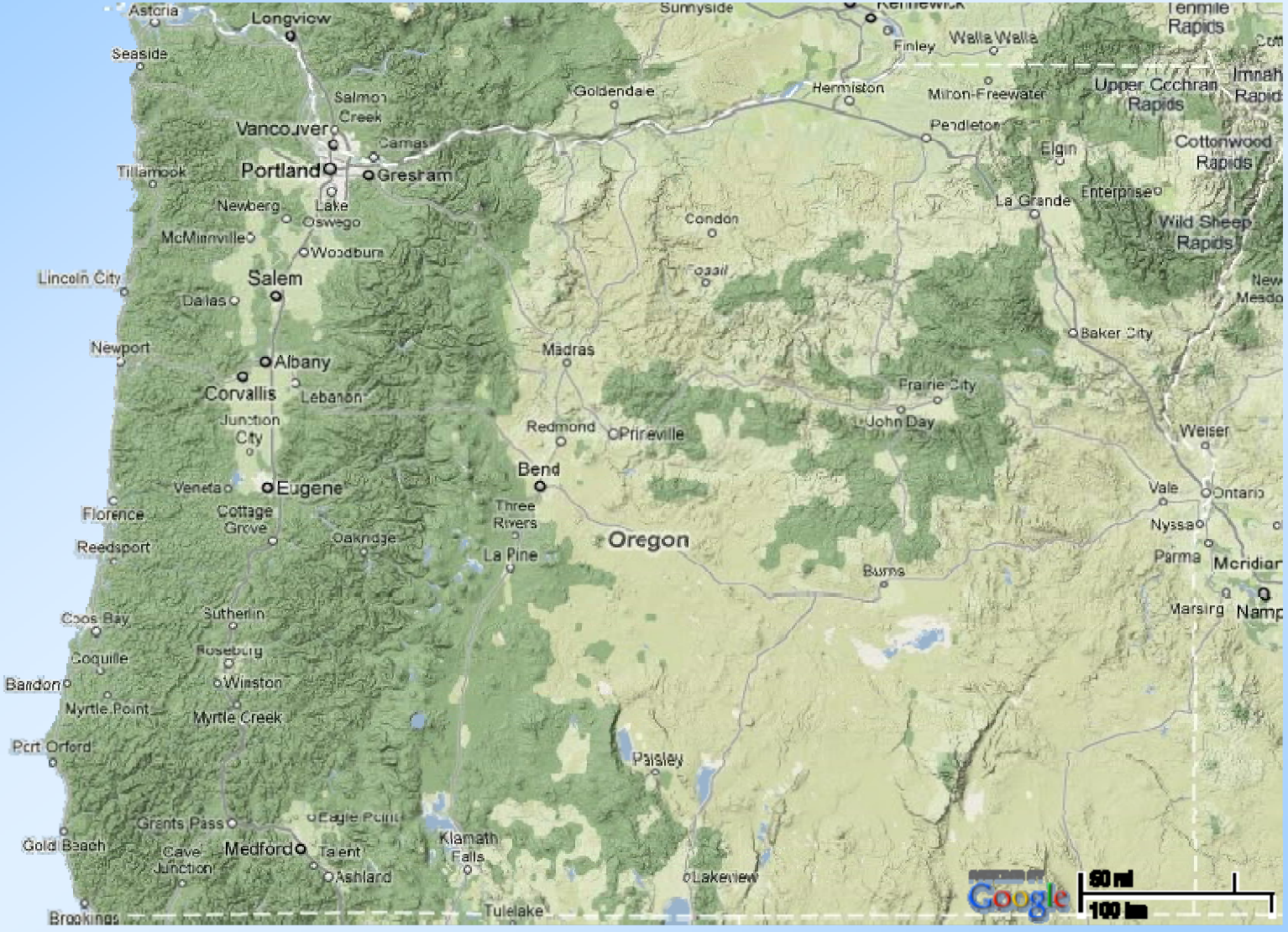
Uses for Continuous Monitors

- Data collection for:
  - Filling data gaps
  - Assessing water quality
  - Detecting seasonal patterns
  - Increasing process-based knowledge
  - Analyzing trends
  - Modeling
- Real-time feedback:
  - Operation of dams and treatment plants (regulatory feedback)
  - Flow augmentation decisions
  - Forecasting
- Calculation of loads & other constituents via correlations

photo by USGS

USGS Continuous Monitors in Oregon



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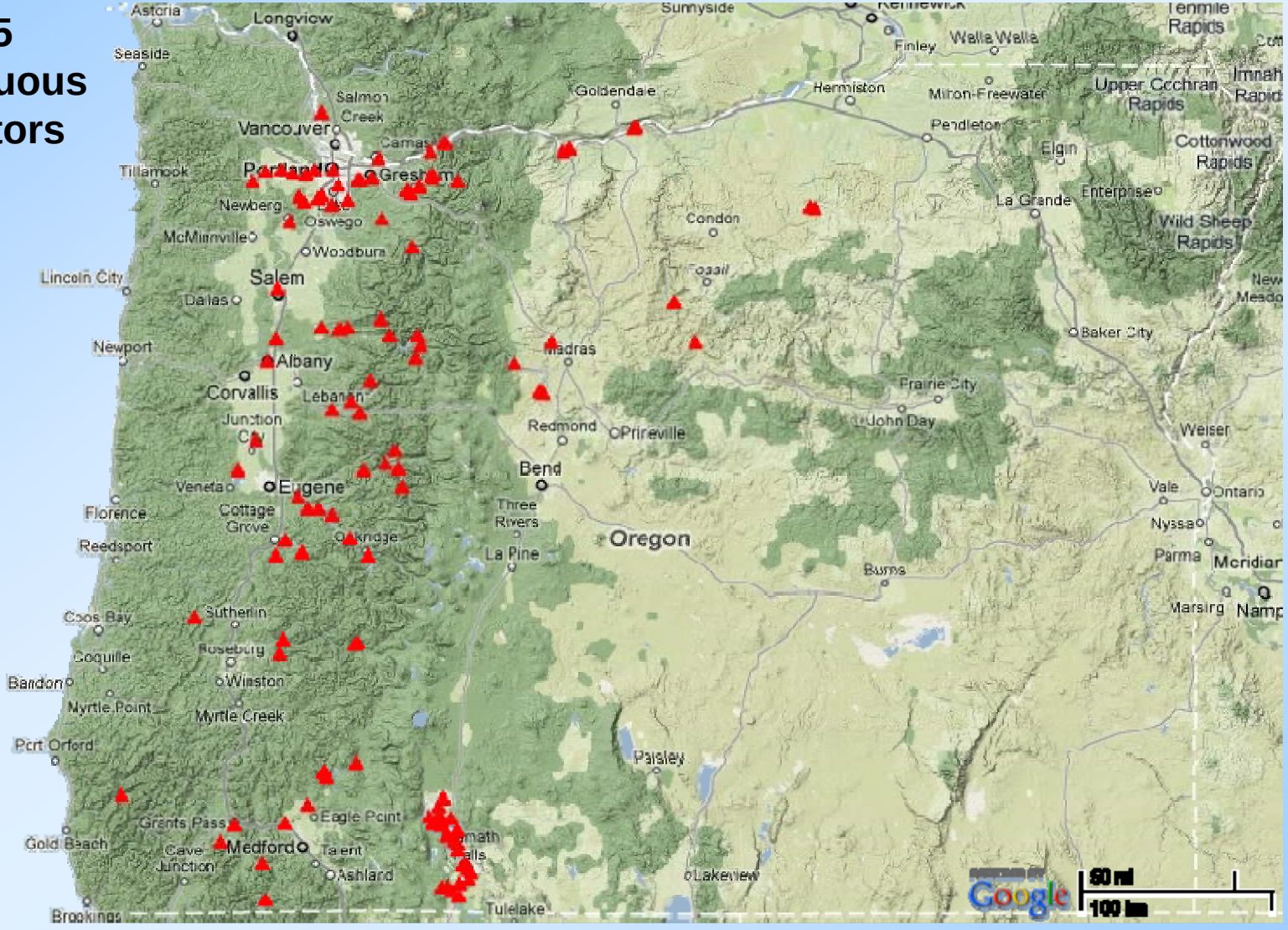
Water Temperature

125 continuous monitors



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Total Dissolved Gas

8 continuous monitors

Columbia River at Bonneville Dam

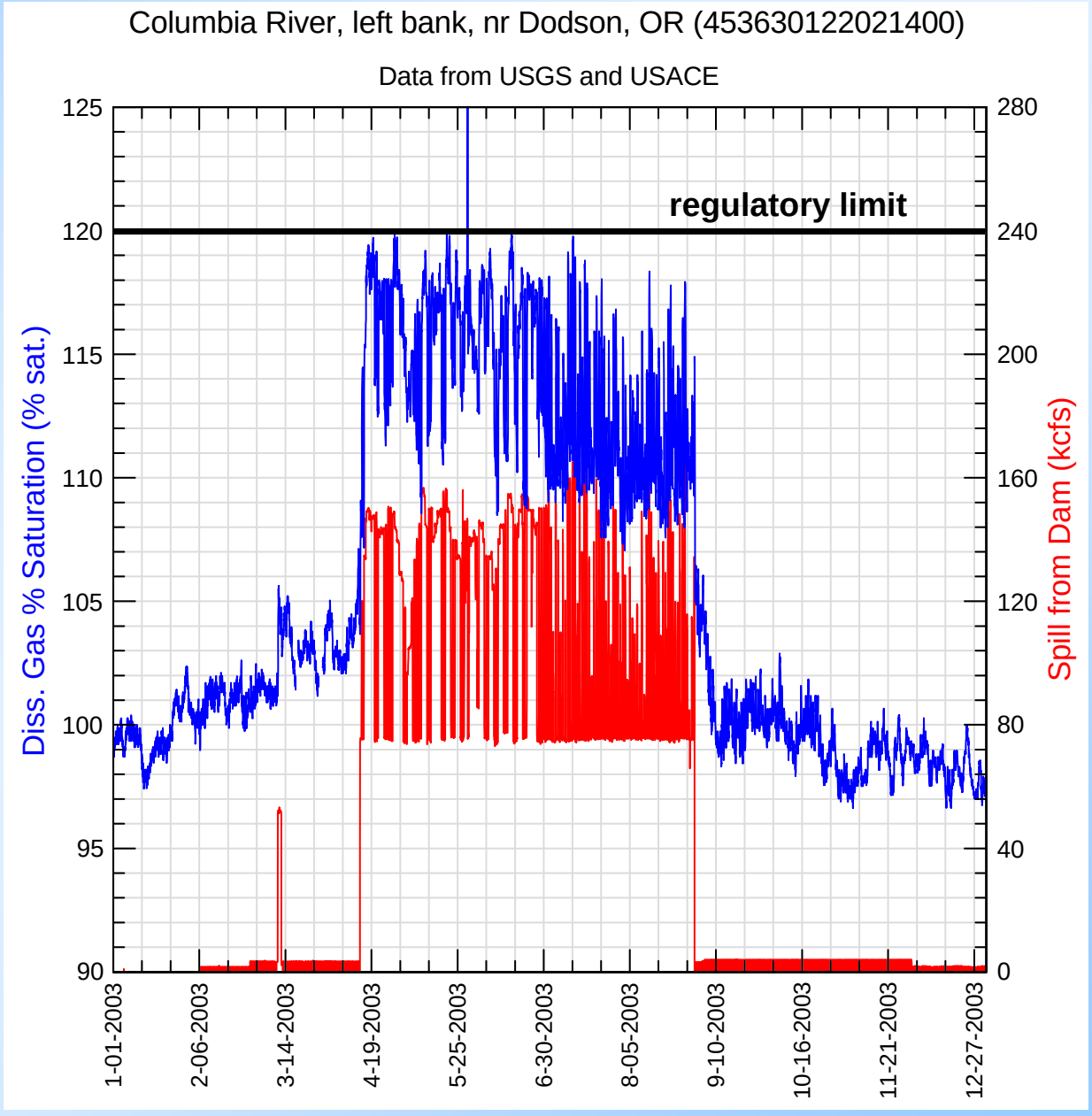
USGS

photo from U.S. Army Corps of Engineers

Total Dissolved Gas

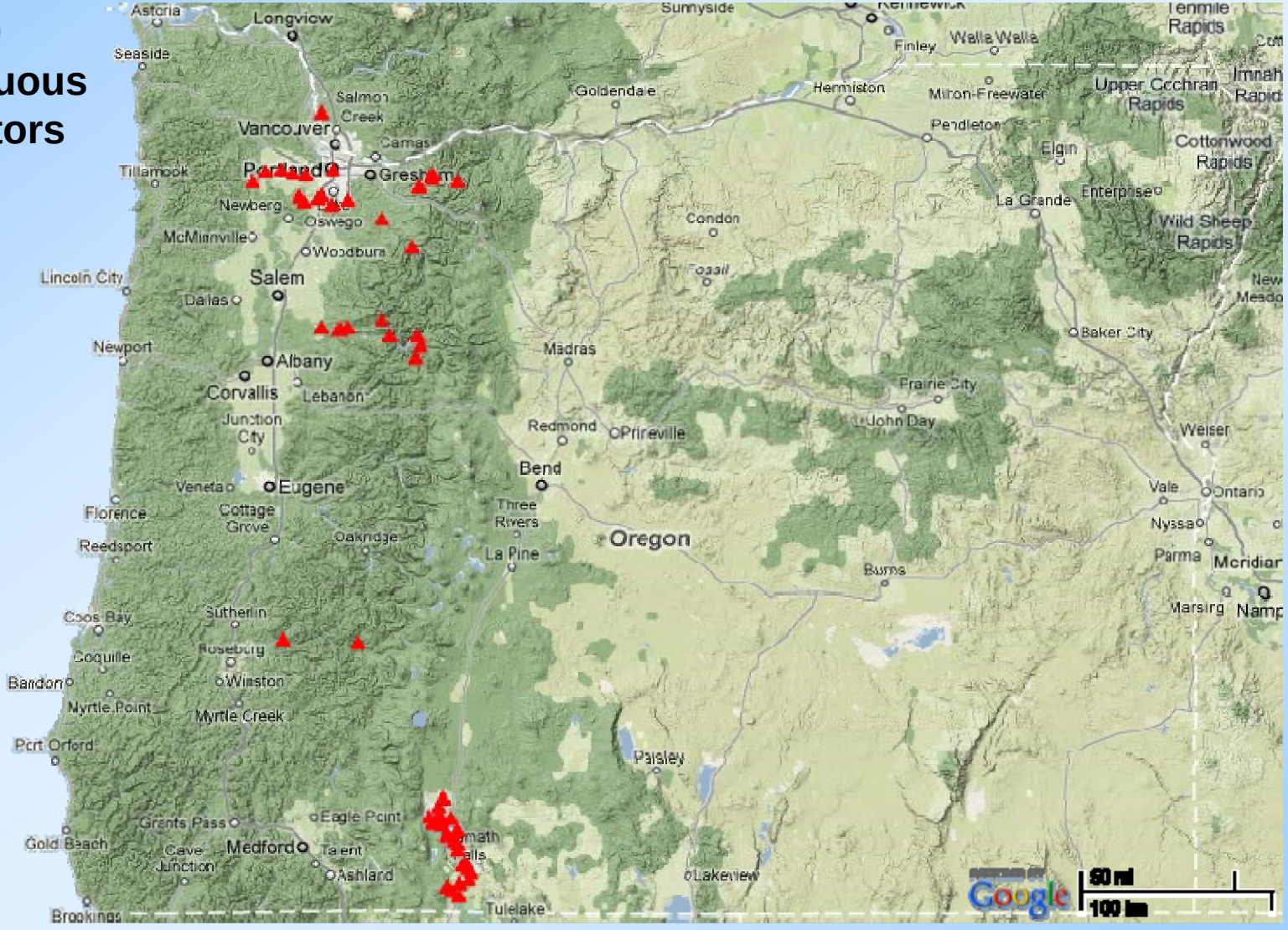
Used for operational & regulatory feedback for dam releases

USGS **(photo from USGS)**



Specific Conductance

60 continuous monitors



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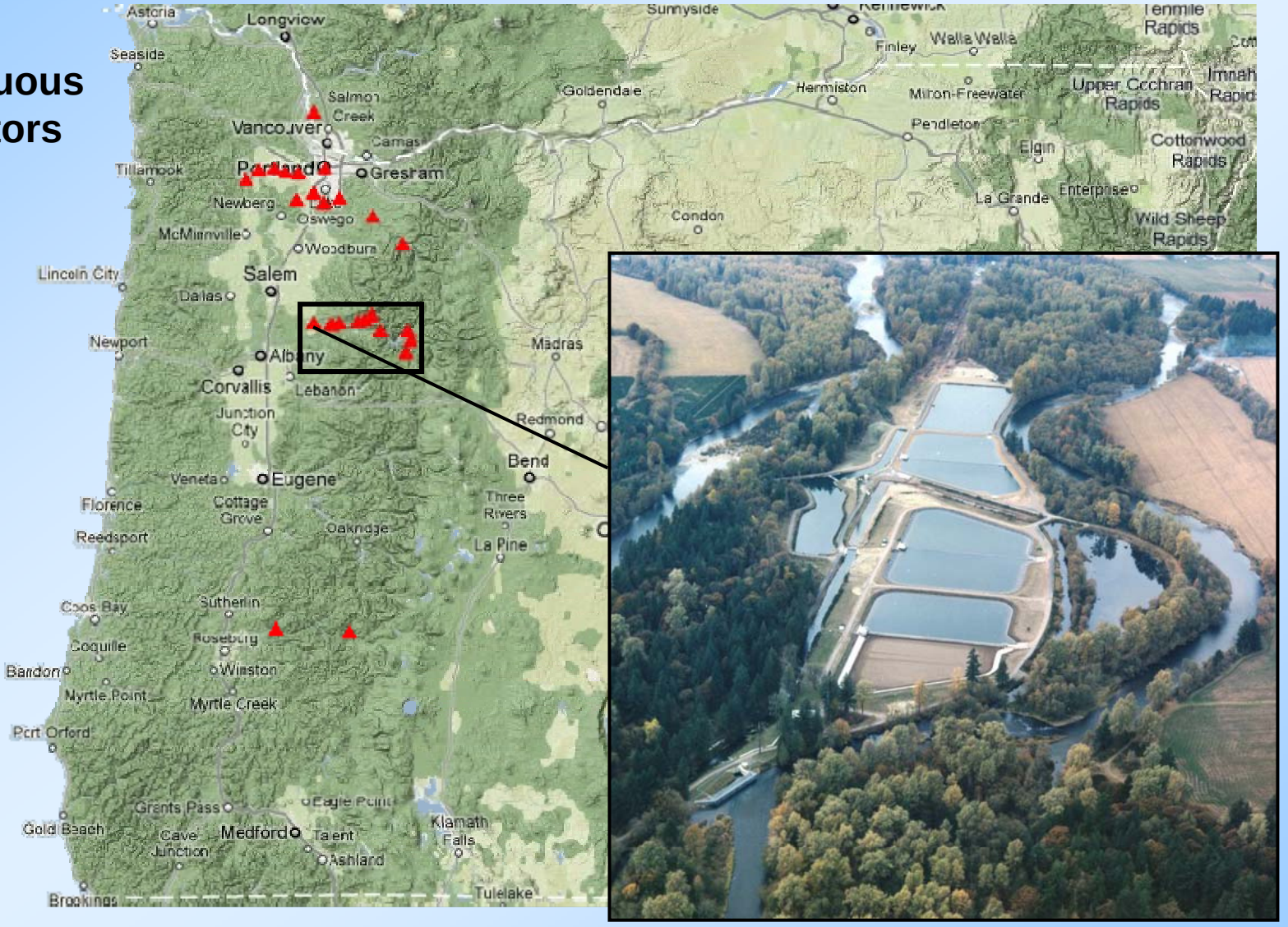
Turbidity

27 continuous monitors



Geren Island drinking water treatment facility

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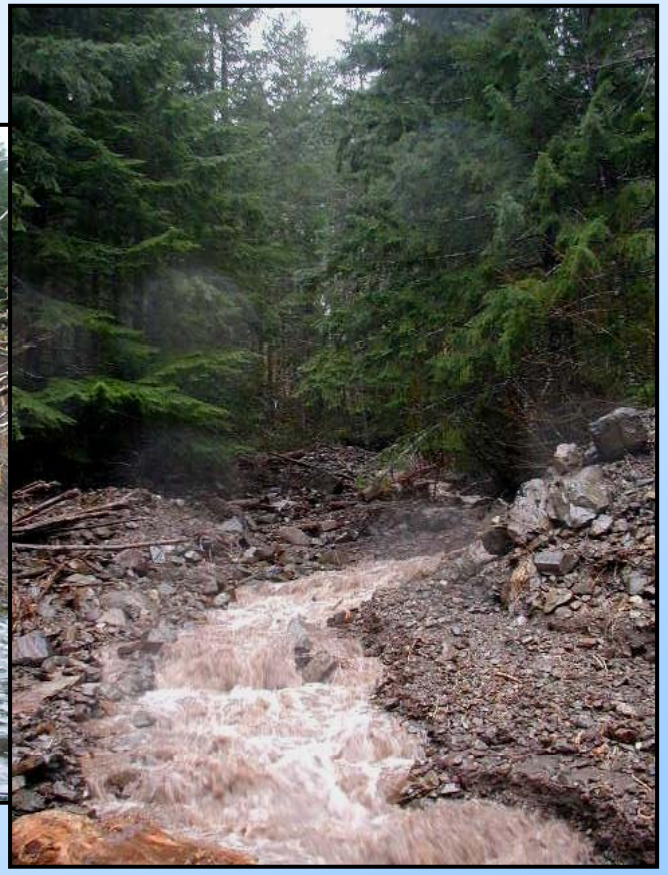
photo from City of Salem, OR

Suspended sediment sources are many and varied…

Road Failures

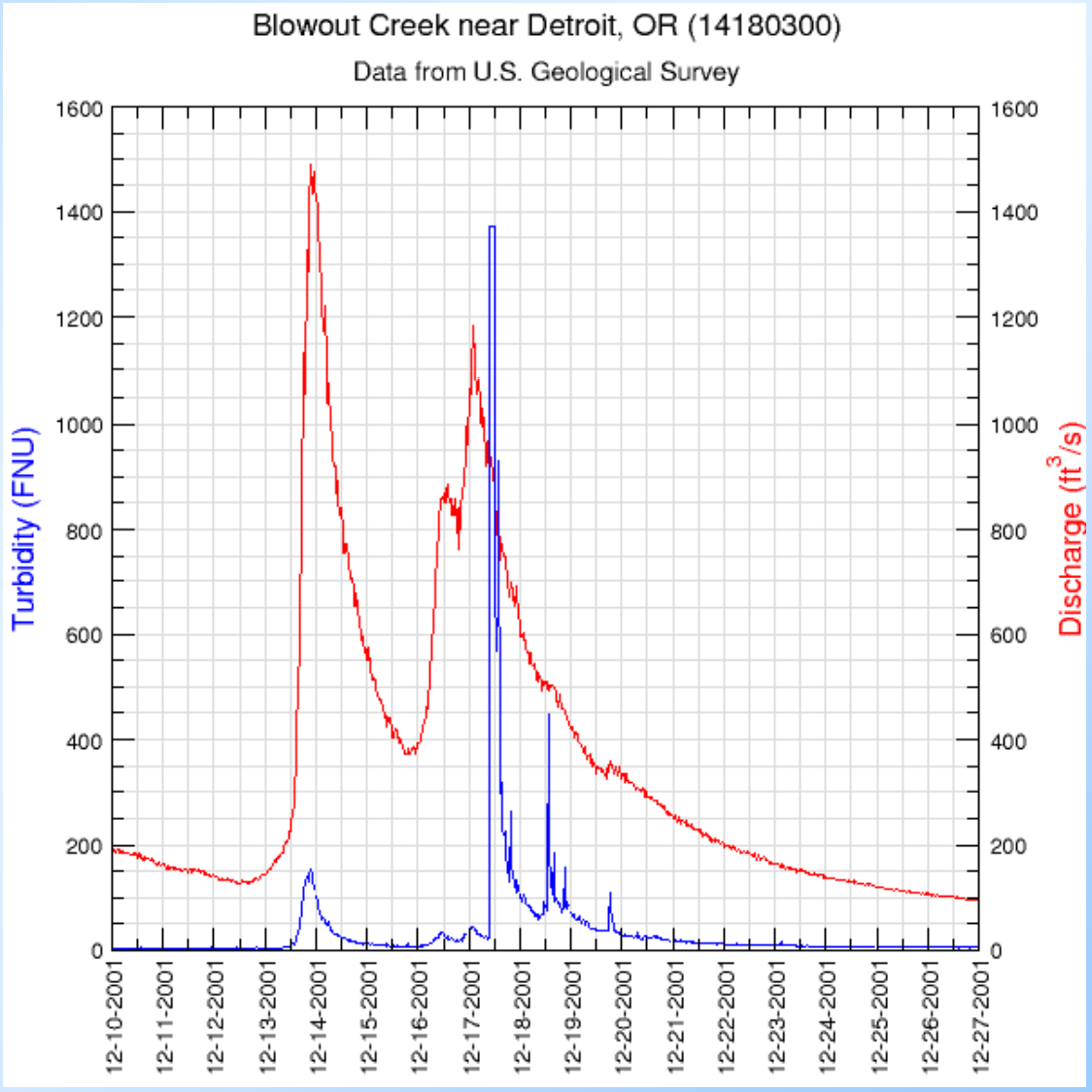
Landslides / Earth-flows

Debris Flows



USGS (photos from USGS)

Monitoring Provides Early Warning, Helps ID Sources, Quantify Loads



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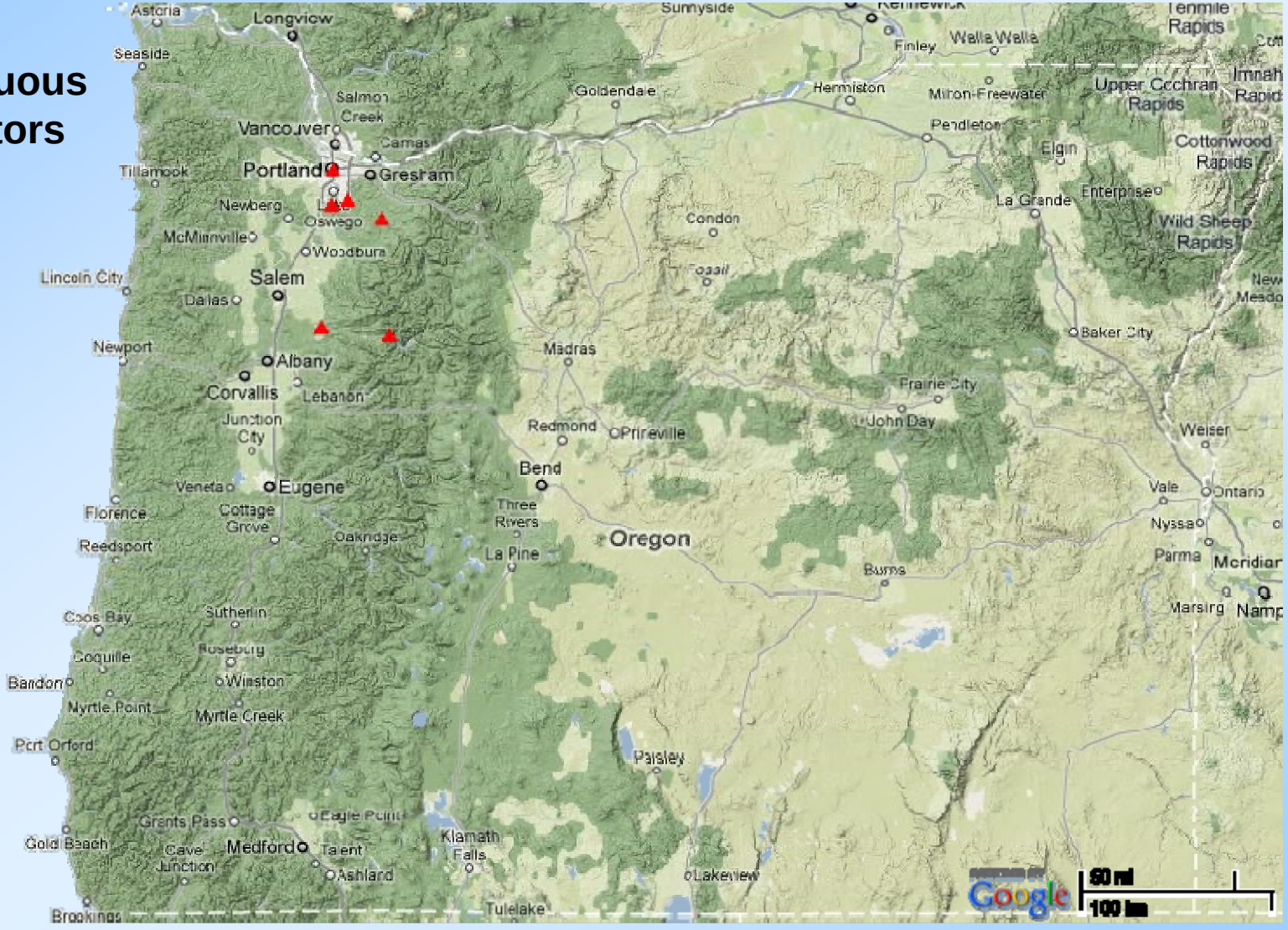
Chlorophyll

6 continuous monitors



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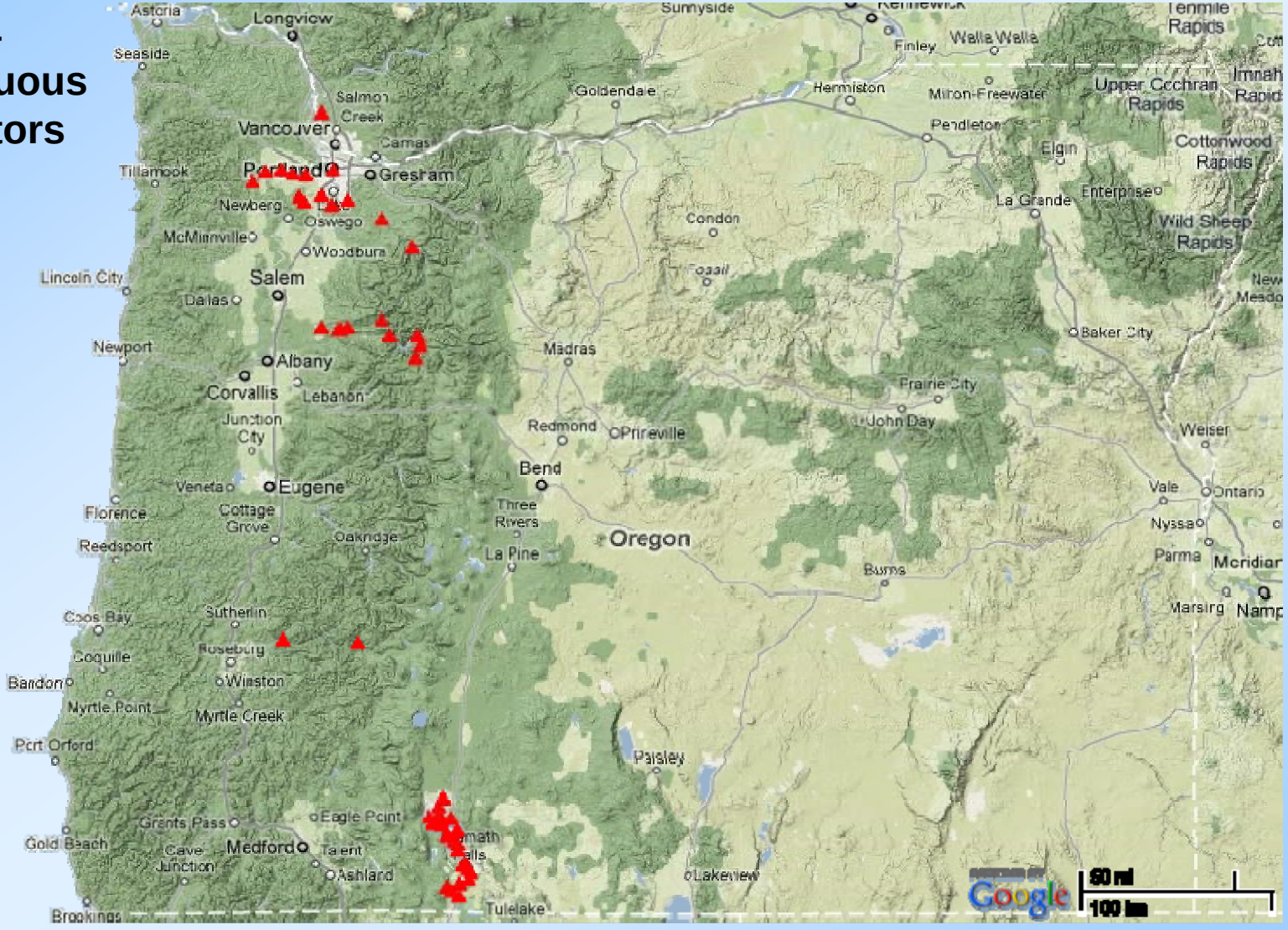
pH

54 continuous monitors



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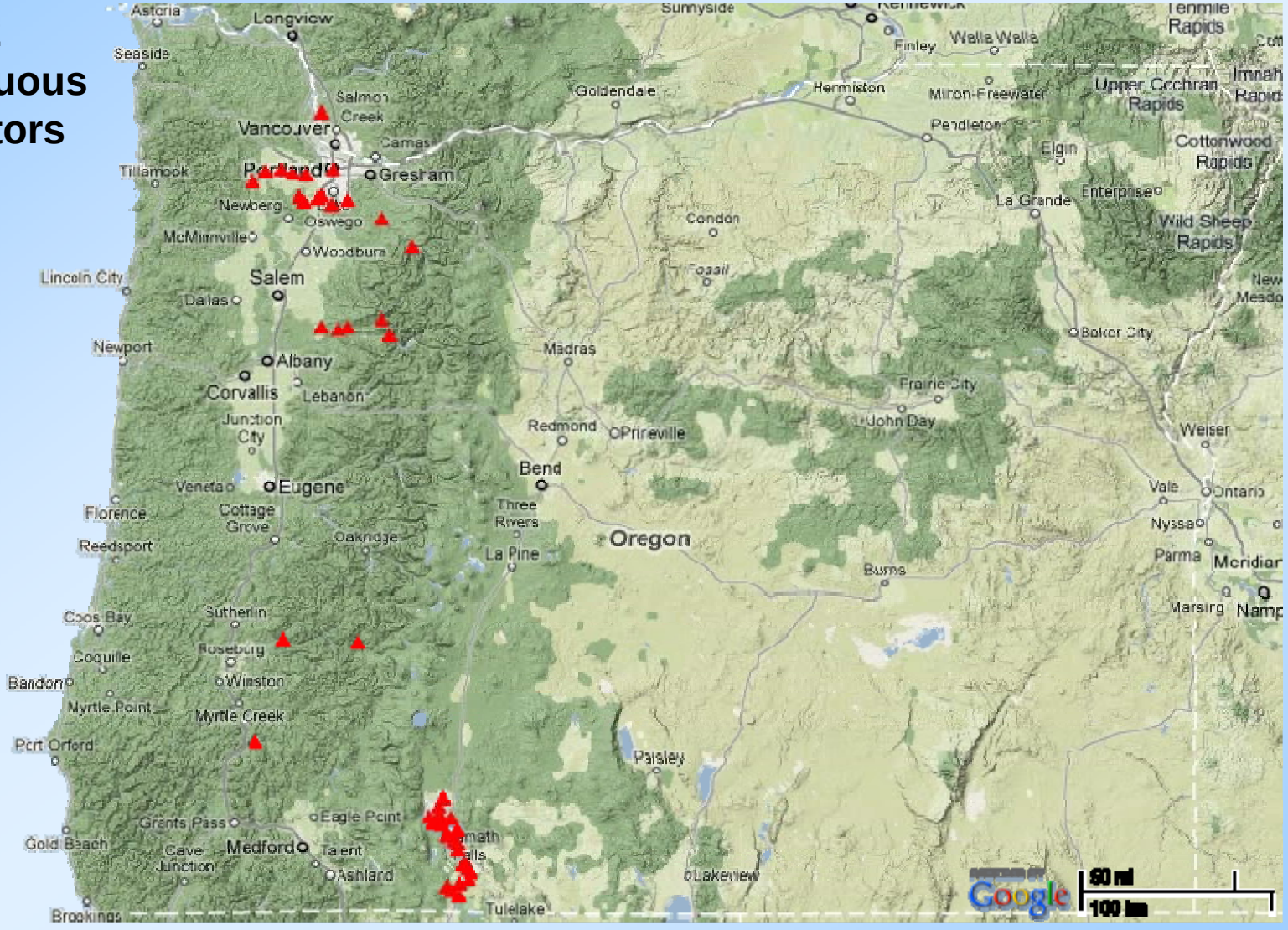
Dissolved Oxygen

52 continuous monitors



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Upper Klamath Lake

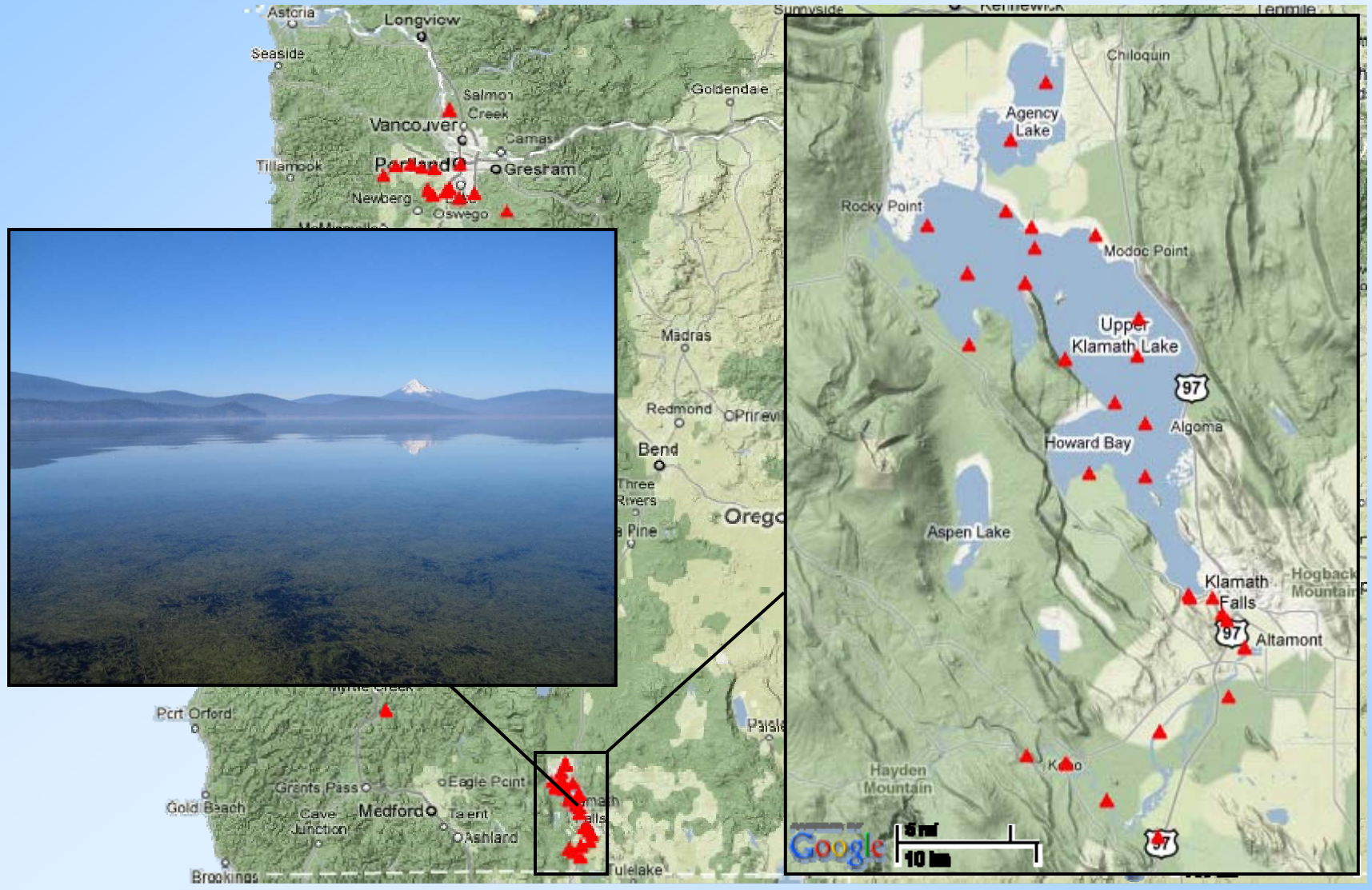

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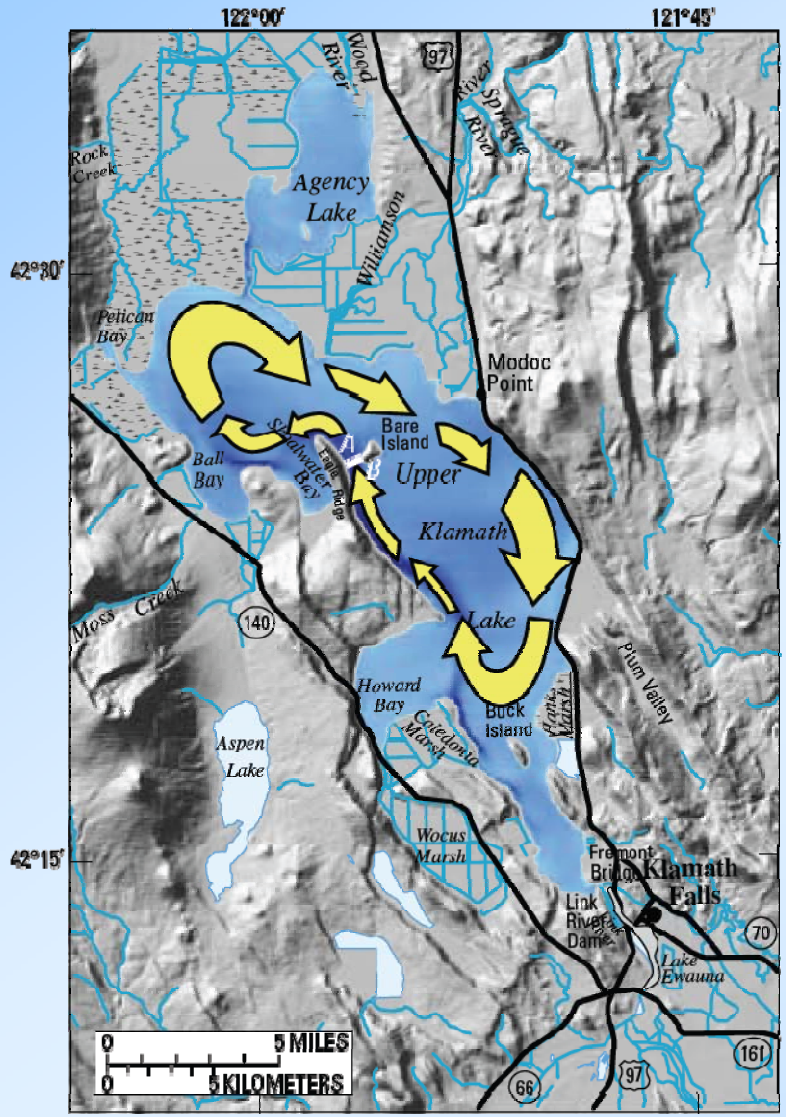
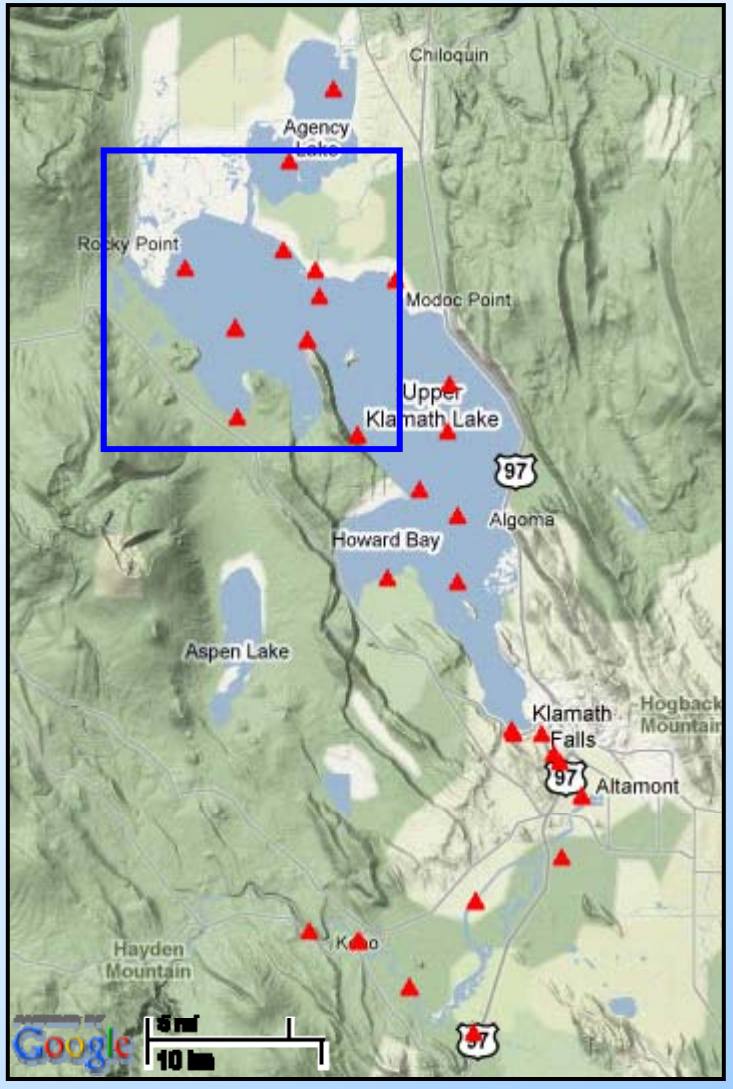
photo by Mary Lindenberg, USGS

Upper Klamath Lake





from Wood, Hoilman, and Lindenberg (2006)

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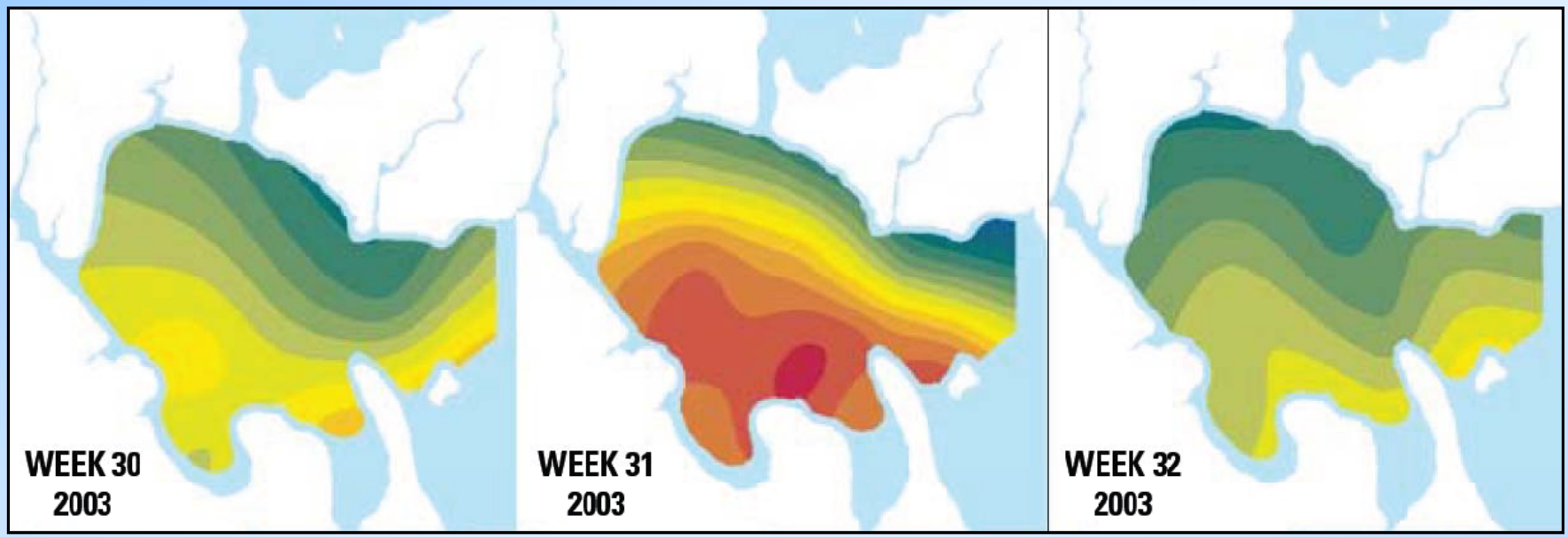
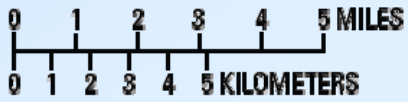
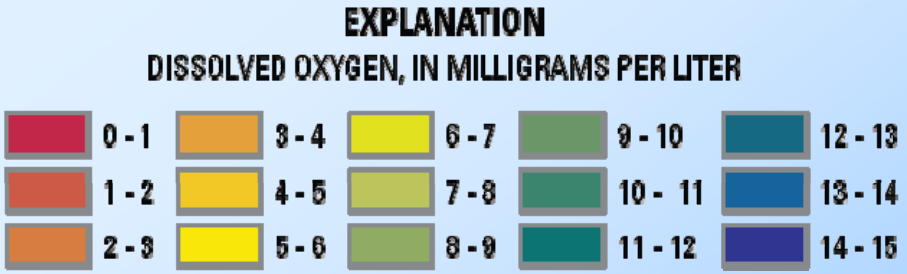
DO Patterns in Upper Klamath Lake







Continuous monitors are critical for measuring and understanding the spatial and temporal patterns of water quality in UKL.

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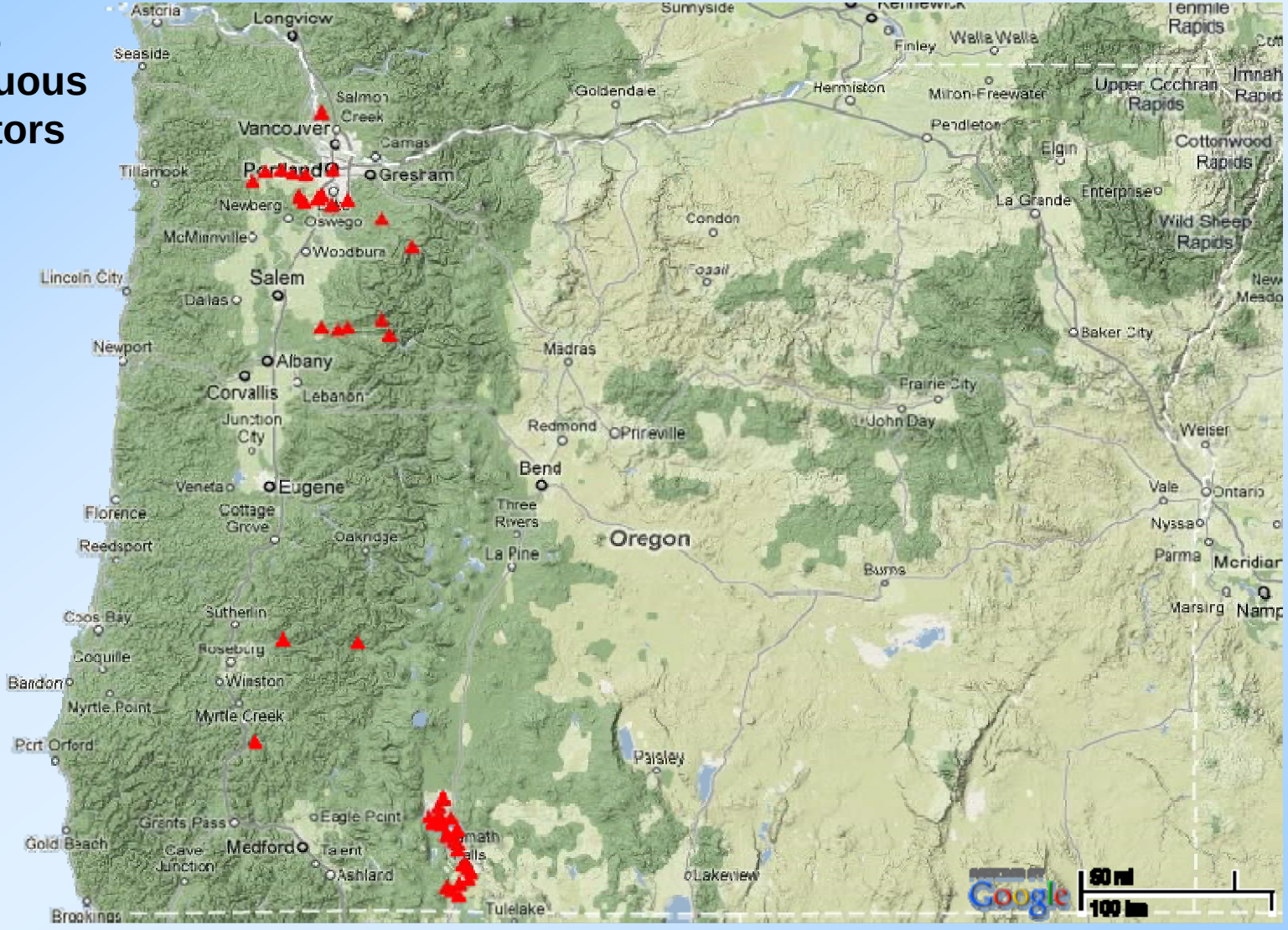
from Wood, Hoilman, and Lindenberg (2006)

Dissolved Oxygen

52 continuous monitors



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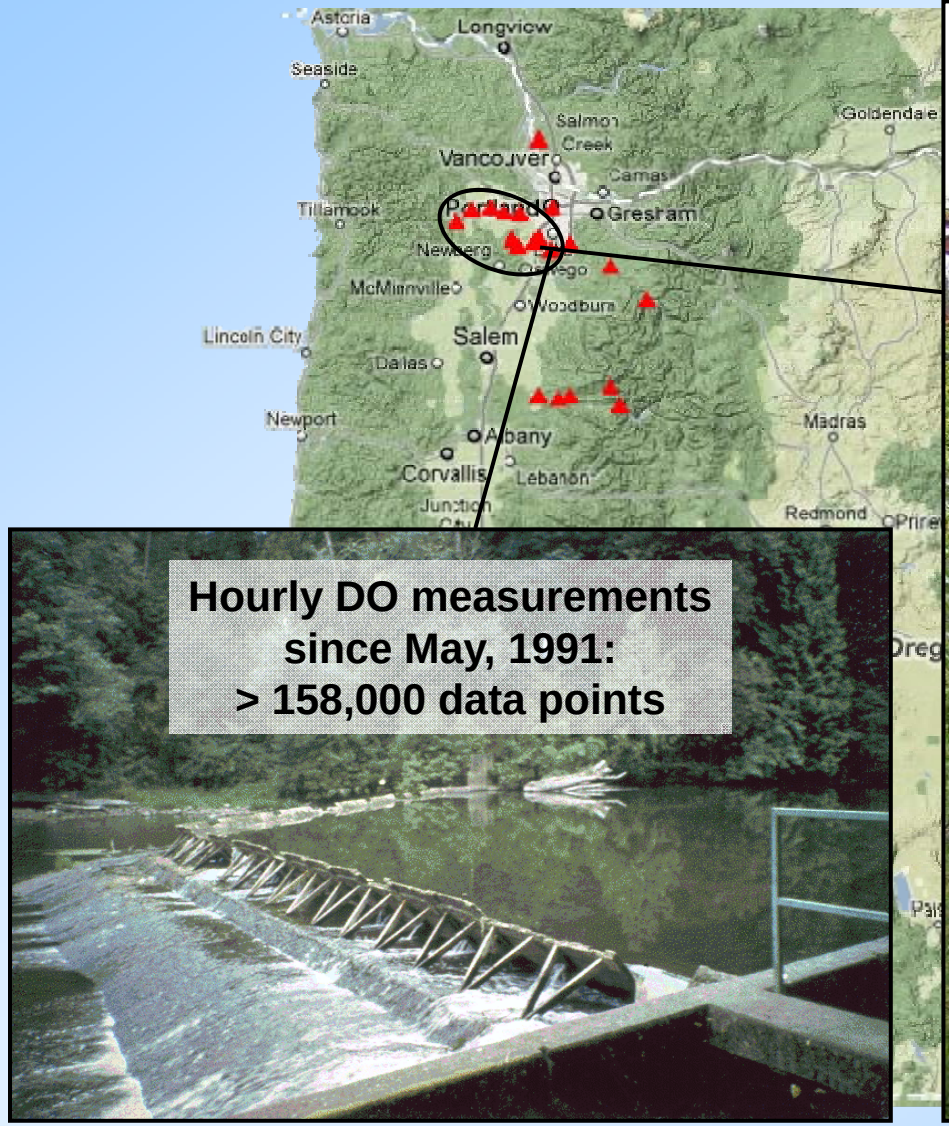
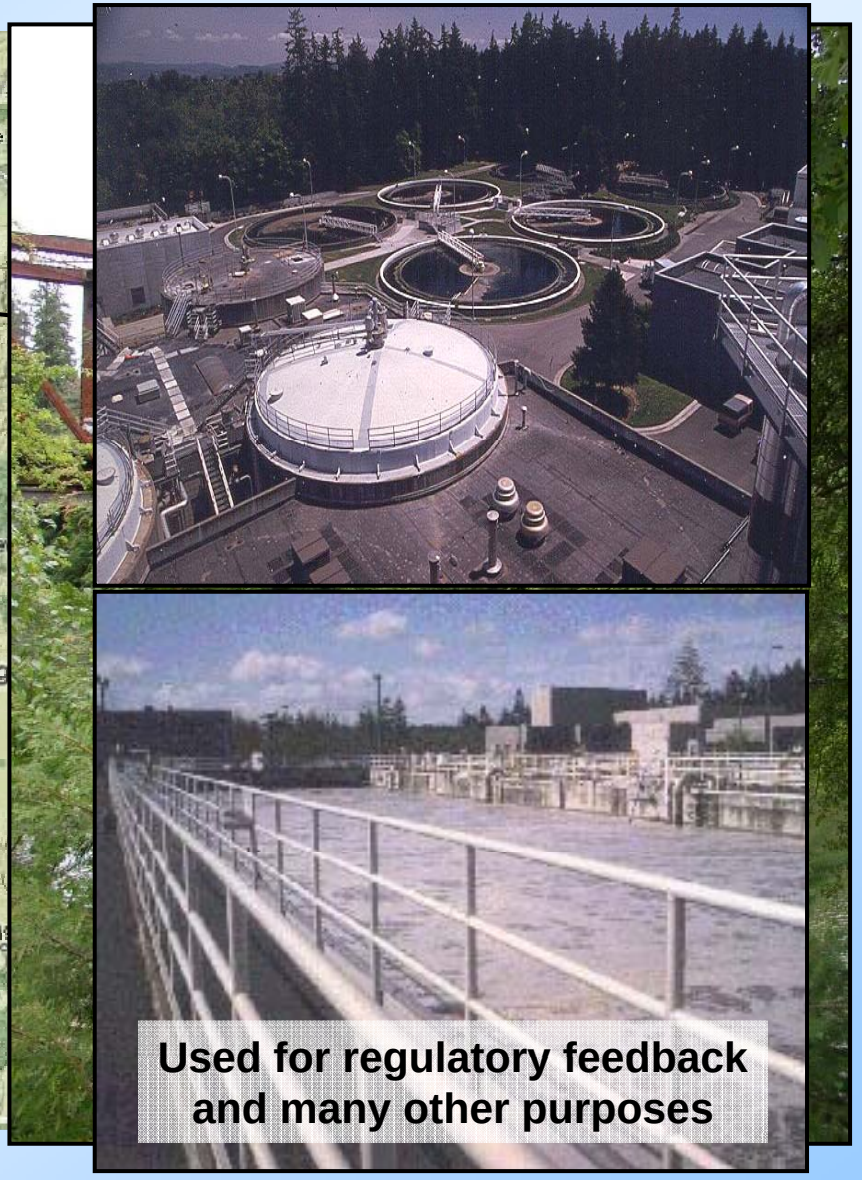
Tualatin River Basin





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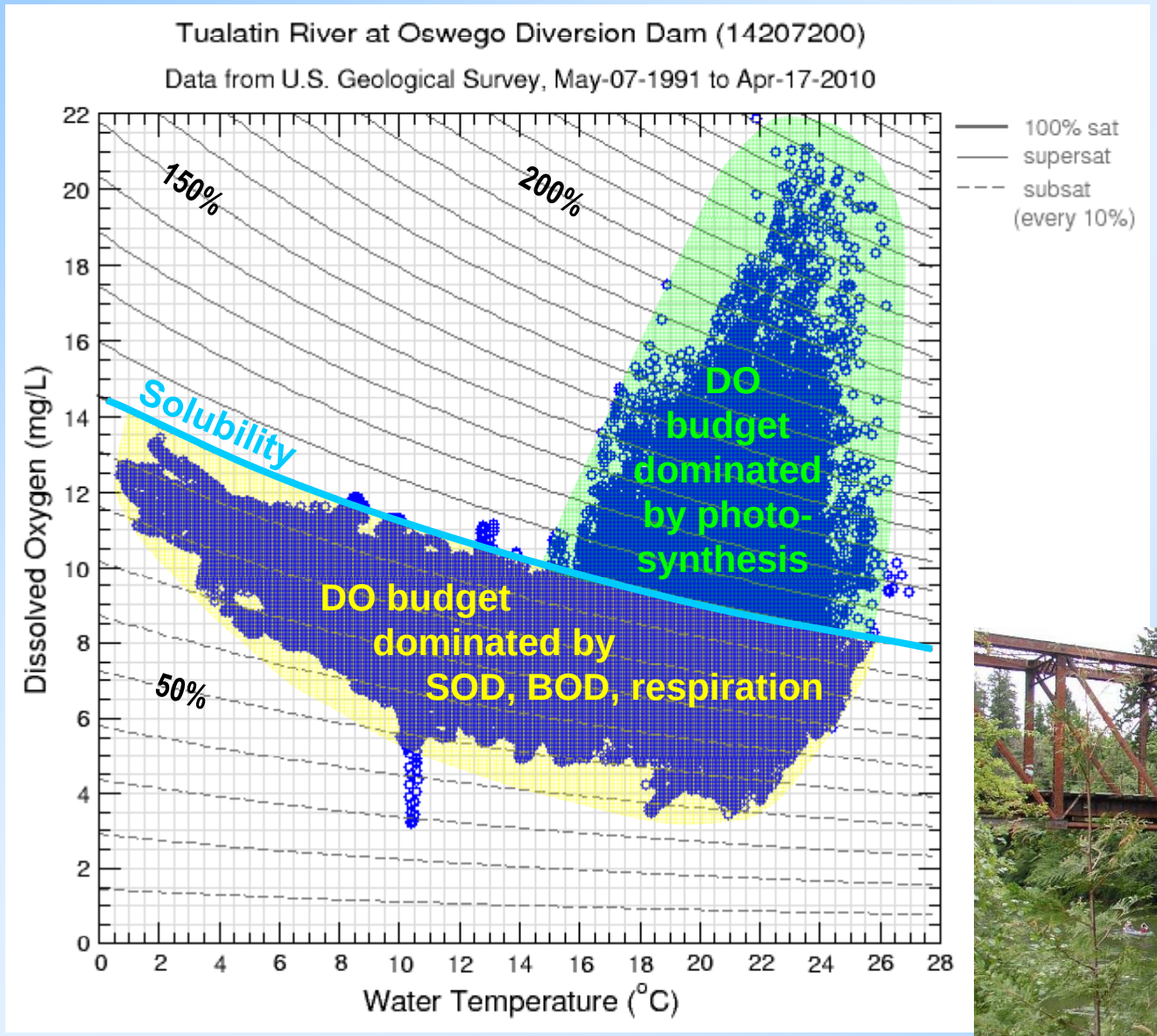
photos by Stewart Rounds, Dennis Lynch, and Denny Wentz, USGS

A Useful Plot for Understanding Instream Processes



- Slow reaeration
- Significant SOD and BOD
- Algal growth in summer

photo by Stewart Rounds, USGS

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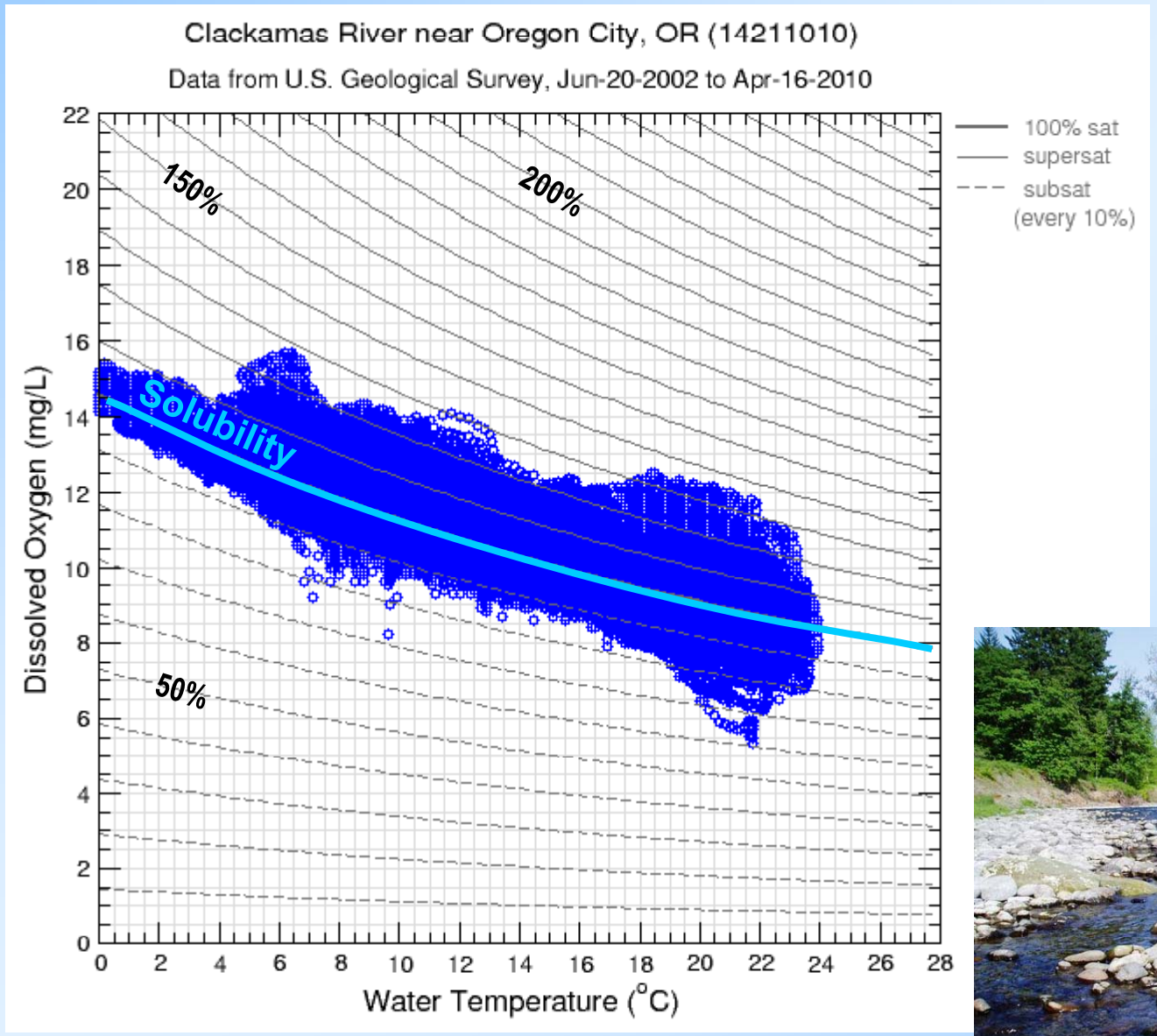
A Contrasting Pattern from a Different River



- Efficient reaeration
- Photosynthesis & respiration are more balanced by reaeration
- Periphyton, not phytoplankton

photo by Kurt Carpenter, USGS

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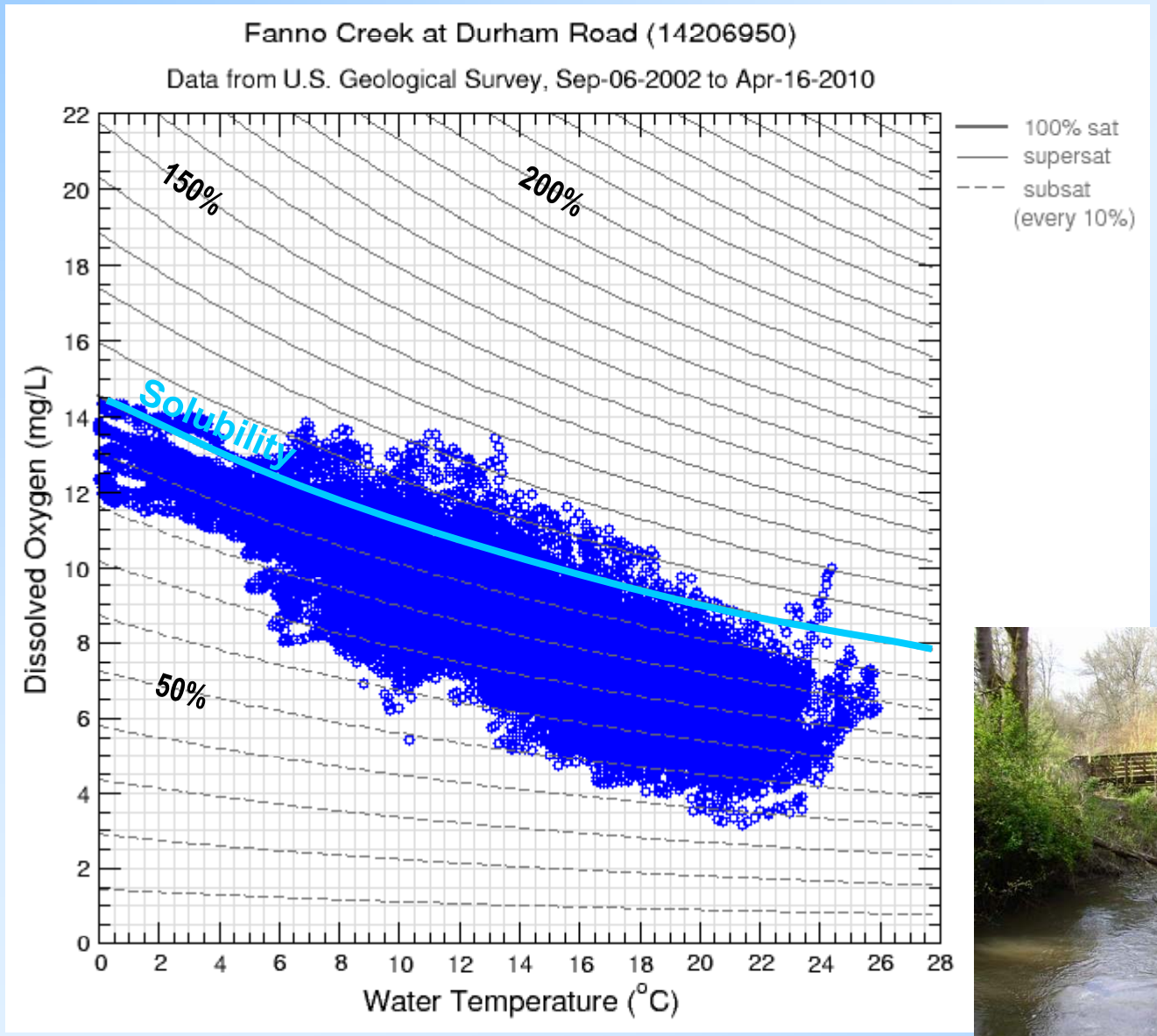
Another Site, Another Pattern



- Slow reaeration
- Large oxygen demands
- Small creek, more shading; therefore, less photosynthesis in summer

photo by Stewart Rounds, USGS

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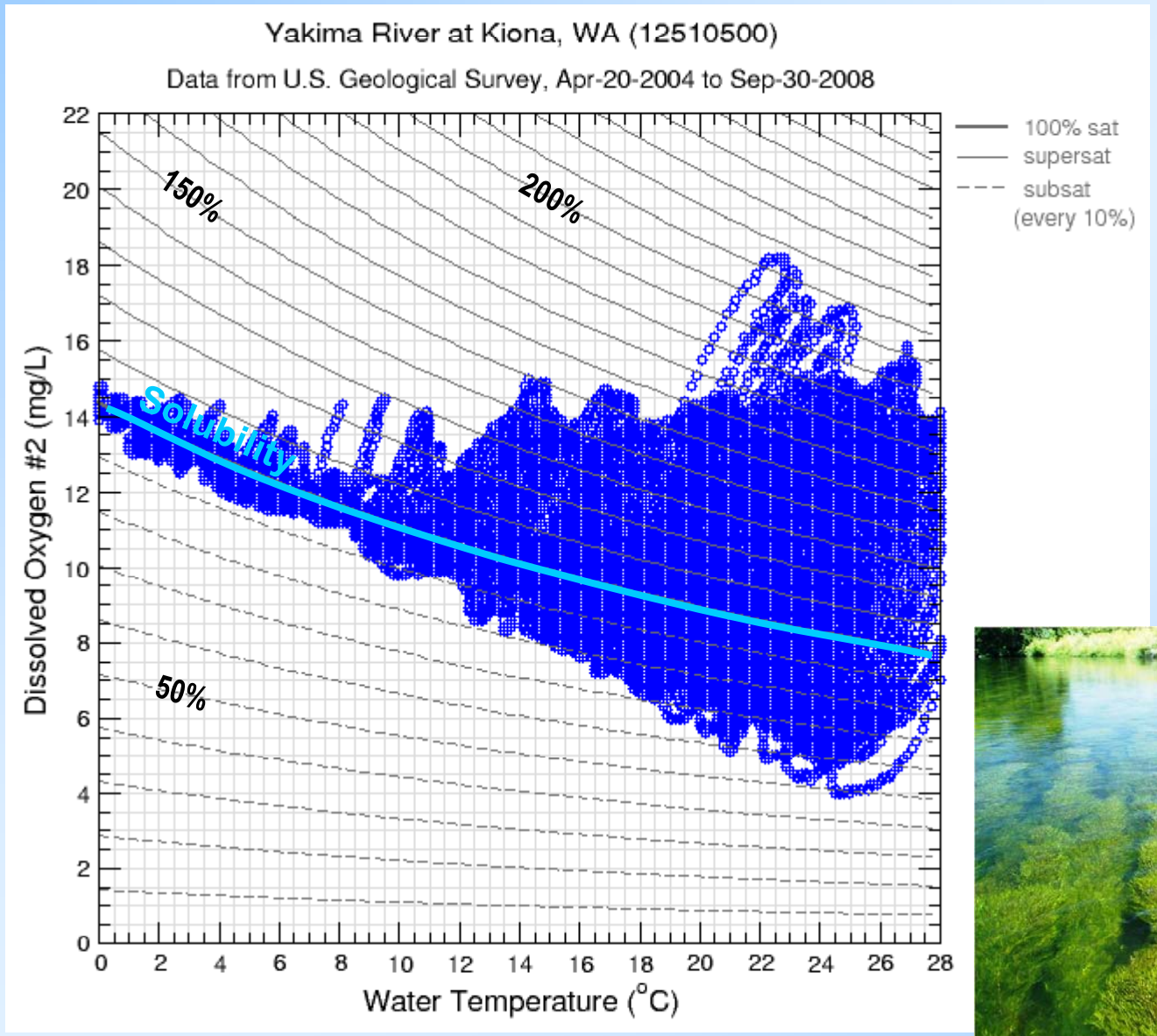
And Another…



- Large daily variations in summer
- Moderate to slow reaeration
- Growth of aquatic plants in summer

photo by Kurt Carpenter, USGS

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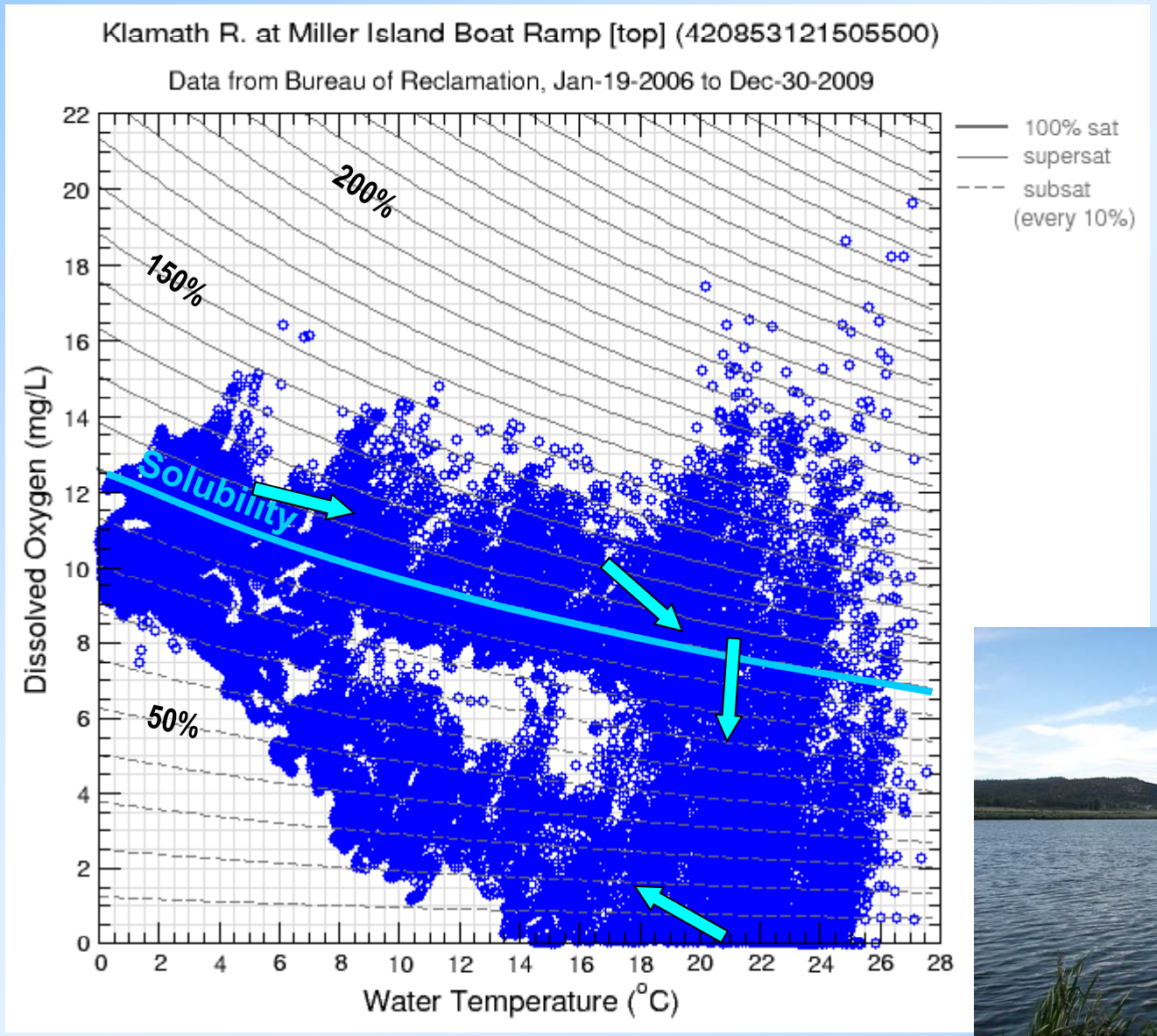
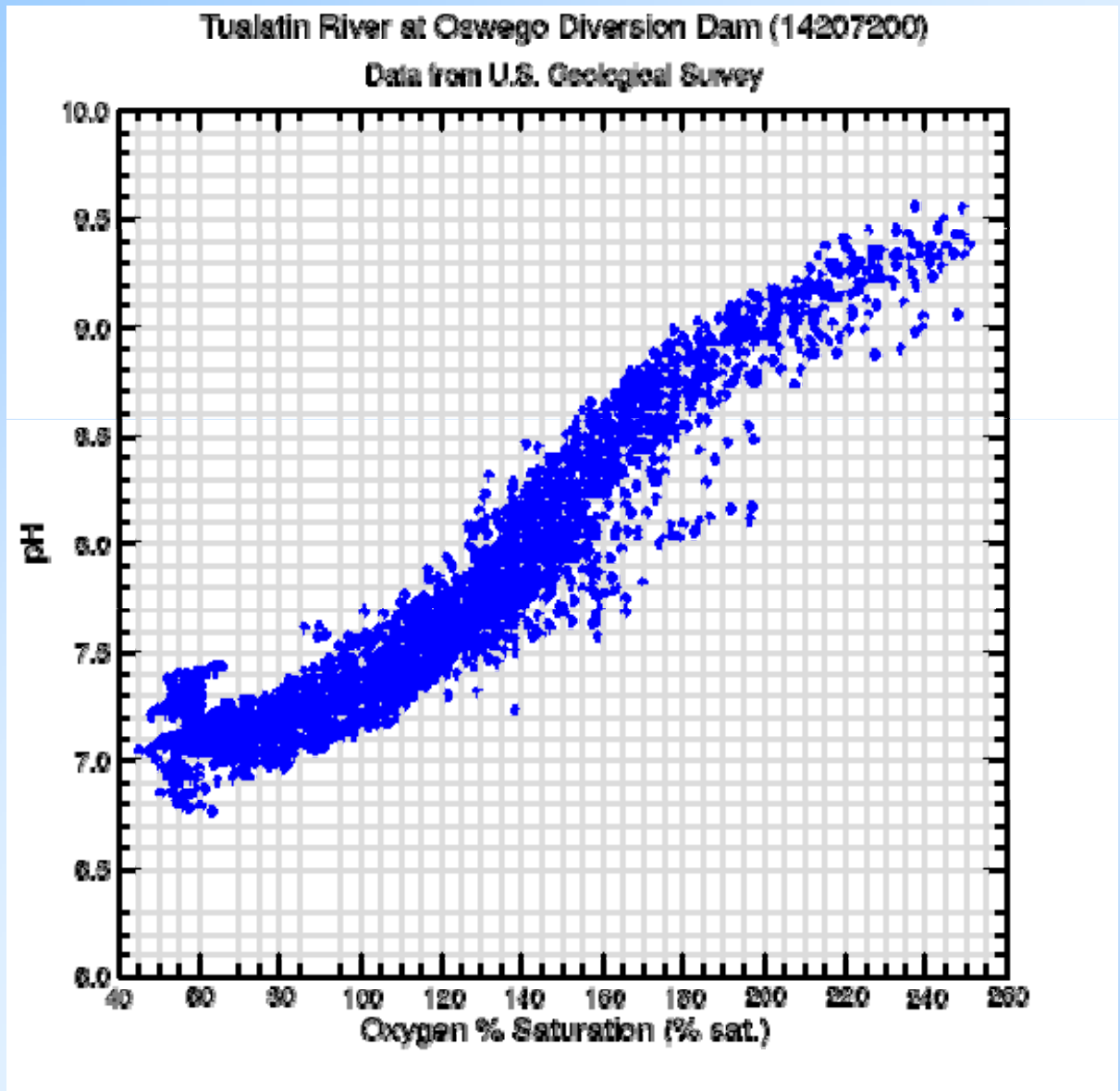
…Last One



- Slow reaeration
- Huge oxygen demands
- Photosynthesis in spring and summer
- Water quality doesn't recover until winter

photo by Dean Snyder, USGS

Explore Your Data!



- Data from summer of 1992
- Inflection is evident, as in carbonate equivalence point of a titration curve

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Take-Home Message

- **Continuous monitors provide rich datasets for:**
  - Filling data gaps at fine temporal scales
  - Assessing water quality
  - Detecting temporal variations (seasonal, daily, event, etc.)
  - Triggering sample-collection events
  - Feedback for regulatory and operational purposes
  - Increasing process-based knowledge
  - Providing data for modeling
  - Forecasting water quality
  - Estimating concentrations of unmeasured constituents

Time-dense information to improve the understanding and management of our water resources

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Andy's Three Questions

- **Where do we need to go?** **(instruments, protocols, databases, etc?)**
  - **Use continuous monitors where they are most effective**
  - **Cheaper! Better! Faster!**
  - **Need new and better probes:**
    - longer periods between calibrations
    - more resistant to fouling (fewer site visits → lower cost)
    - more types – matched to water-quality & research objectives
  - **Need models and methods to mine the information content of the data (surrogates, process-related information, etc.)**
  - **Need to make every data point available online, with quantitative uncertainty estimates for each point**

Andy’s Three Questions (cont.)

- **Why aren't we there?** (technological and other impediments?)
  - Expense
  - Need time to develop new technologies
  - Need upgrades for databases & data distribution procedures
- **How do we fill these gaps to get where we need to go?**
  - Reduce barriers to use (decrease costs, streamline processes)
  - Demonstrate the utility of continuous monitors to researchers and management/regulatory agencies
  - Develop new applications and methods to mine information
  - Upgrade databases and online tools